Use of remote sensing to determine target populations of tsetse in Senegal

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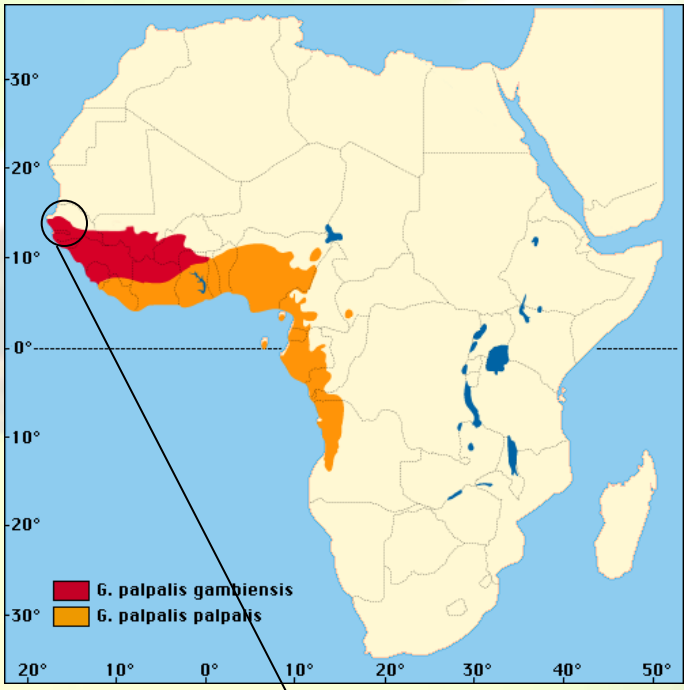
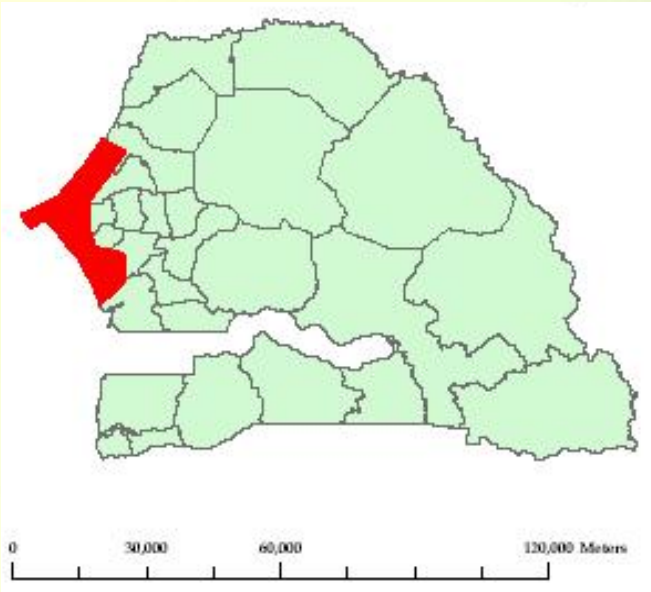
Cliché O. Esnault

« Quels outils pour un changement d'échelle dans la gestion des insectes d'intérêt économique ? »
Montpellier, 4 & 5 octobre 2011

1.Context

- Senegal = North-Western edge of *G. palpalis gambiensis* distribution
- The Niayes area is located along the Atlantic coast (30 to 35 km width)
- Mean temperatures 25-30°C, RH 60-80% and annual rainfalls 200-500mm
- Important cropping and cattle breeding area (exotic dairy cattle), but cost-effectiveness threatened by trypanosomoses
- A tsetse control campaign launched by the Direction of Vet Services in 2008
- First step: feasibility study





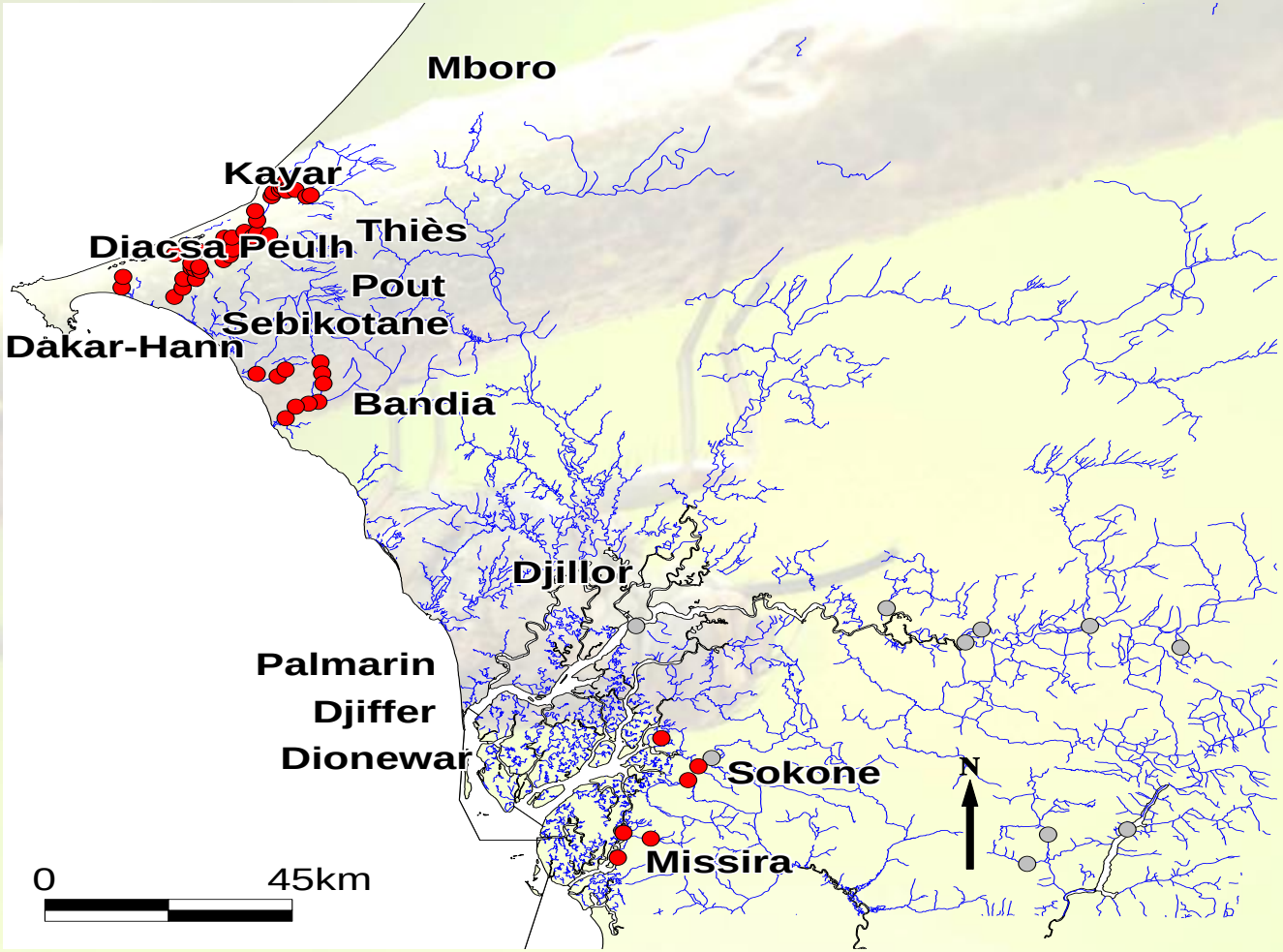
2. Objectives of the feasibility study

- Define tsetse distribution and ecology in the study area (7.350km^2)
  - Use of ecological data
  - Use of modern geomatic tools (remote sensing/GIS/GPS)
  - Optimize cost/quality of the entomological baseline data collection
  - Quantify uncertainty
- Measure gene flow between target and surrounding populations

3. Definition of the target tsetse population: entomological sampling scheme

- Obtain all the historical data and references available on the targeted insect species and study area
- Define suitable landscapes
- Map suitable landscapes using remote sensing
- Build the sampling protocol

Historical data



Historical distribution of G. palpalis gambiensis in the study area (from the digitalization of S. Touré reports, 1972-1979)

Define suitable landscapes

(preliminary surveys)

Natural forest galleries

Riverine tickets

Swampy forests

Palm-tree crops

Citrus and mango-try crops

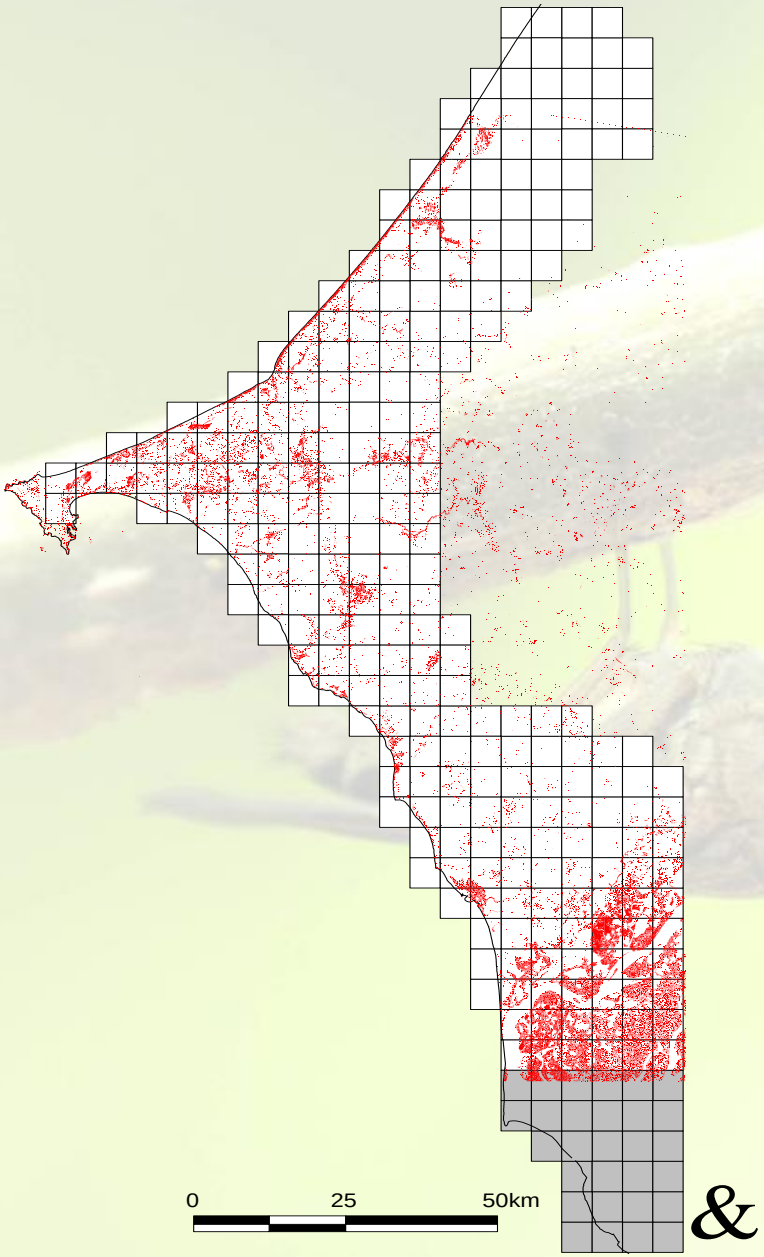
Mangrove forests

Phytosociological censes

Mapping suitable landscapes using remote sensing

- Common characteristic of all suitable habitats:
  - Availability of water during the dry season (surface water, hydrological network, watering of tree-crops)
- Discrimination methodology:
  - High resolution satellite images at the end of the dry season (Landsat 7 ETM+ from April 2001, source CSE)
  - Supervised classification: discrimination of the landscapes with an intense photosynthetic activity at the end of the dry season.

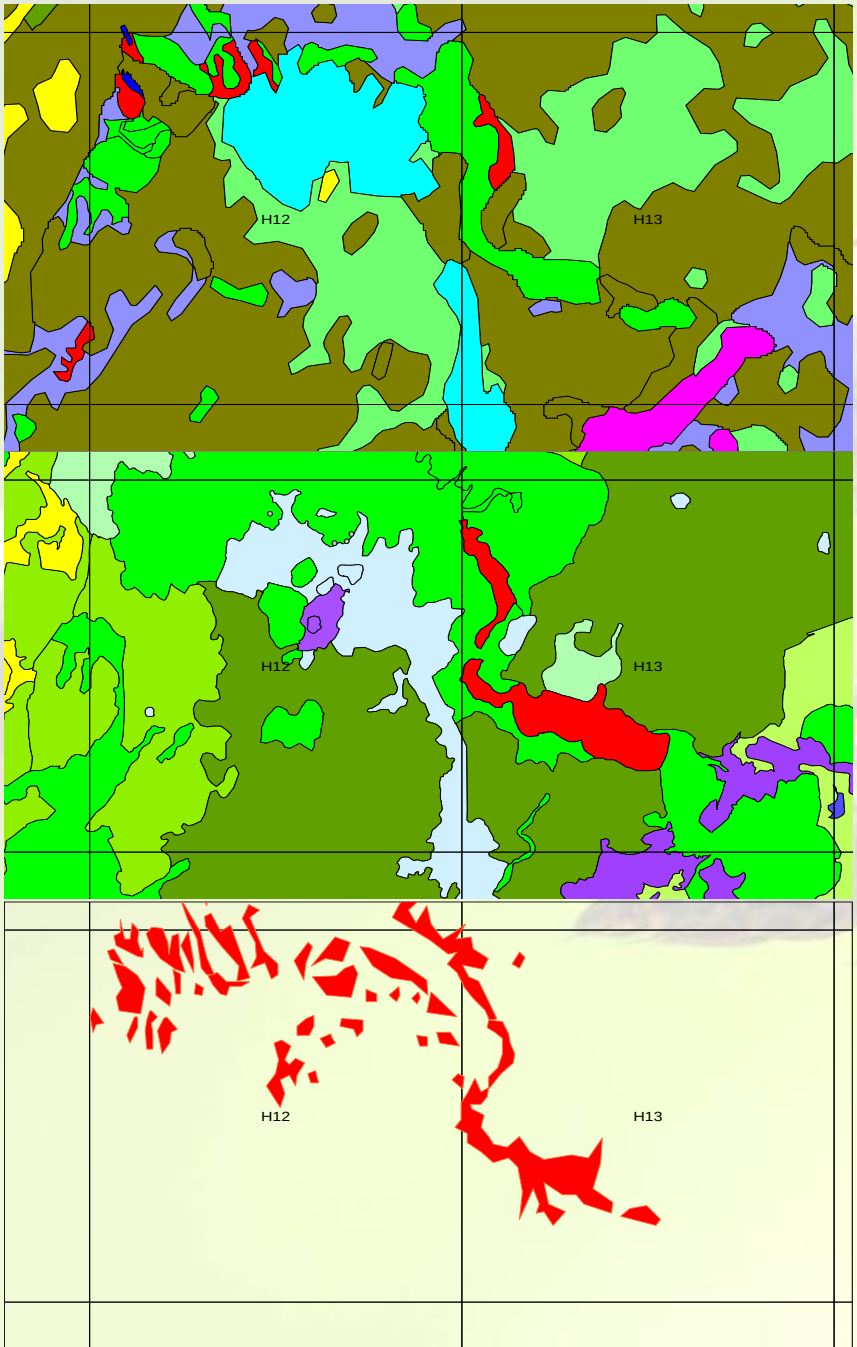
Mapping suitable landscapes using remote sensing



96% reduction of the sampling area

110 validation sites :
Sensibility 0.96
Specificity 0.43 only

Comparison of various classification methods in Mboro



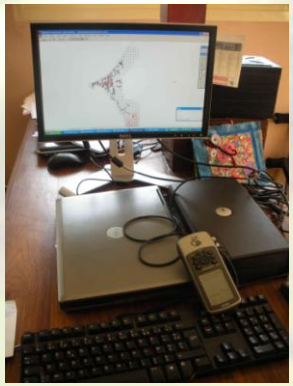
Mapping of the Niayes in 2002 (T. Ba, CSE 2005)

Mapping of the study area for the project (CSE 2007 final version)

Mapping of the dry season wet Landscapes (Bouyer et al. 2010)

5. Build the sampling protocol

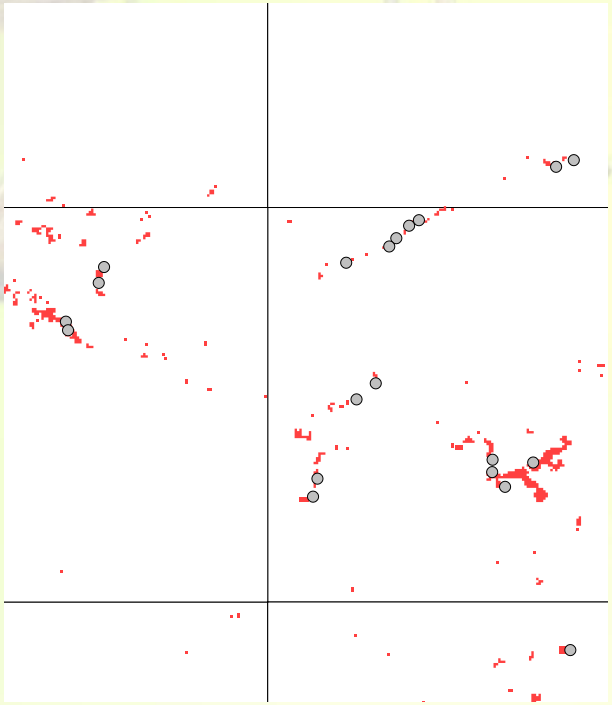
Uploading of the standard grid and the polygons corresponding to the wet landscapes during the dry season in the GPS
Setting traps in all the wet areas in each grid cell assisted by GPS

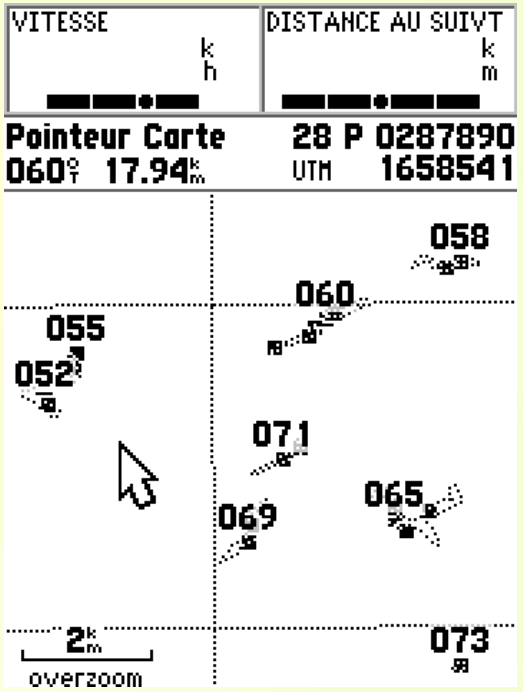


GIS

GPS

GIS → GPS





5. Build the sampling protocol

To be or not to be… absent

In each grid with zero catch, the probability that tsetse are still present is implemented:

$$p = \exp(- S t \sigma \lambda)$$

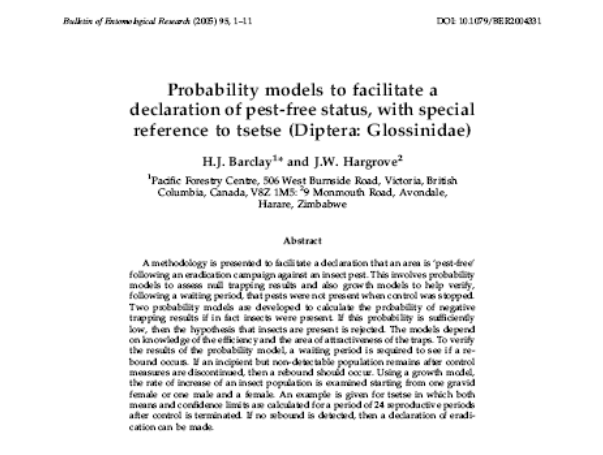
With:

S : number of traps deployed in the total area

t : the number of days for which each trap is operated

σ: the trap efficiency (estimated at 0.01 from Mark-release-recapture protocols)

λ: the population density (number of insects / area of suitable habitat): minimal resident population set to 10 in the absence of control measures



Bulletin of Entomological Research (2005) 95, 1–11 DOI: 10.1079/BER2004331

Probability models to facilitate a declaration of pest-free status, with special reference to tsetse (Diptera: Glossinidae)

H.J. Barclay[1]* and J.W. Hargrove[2]

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Abstract

A methodology is presented to facilitate a declaration that an area is 'pest-free' following an eradication campaign against an insect pest. This involves probability models to assess null trapping results and also growth models to help verify, following a waiting period, that pests were not present when control was stopped. Two probability models are developed to calculate the probability of negative trapping results if in fact insects were present. If this probability is sufficiently low, then the hypothesis that insects are present is rejected. The models depend on knowledge of the efficiency and the area of attractiveness of the traps. To verify the results of the probability model, a waiting period is required to see if a re-bound occurs. If an incipient but non-detectable population remains after control measures are discontinued, then a rebound should occur. Using a growth model, the rate of increase of an insect population is examined starting from one gravid female or one male and a female. An example is given for tsetse in which both means and confidence limits are calculated for a period of 24 reproductive periods after control is terminated. If no rebound is detected, then a declaration of eradication can be made.

GPS

↓

GIS

↓

Implementation of the probability of presence despite 0 catch

↓

Additional sampling

Entomological sampling scheme

To be or not to be… absent

The probability that tsetse are present despite a series of zero catches is defined as:

$$p = \exp(-St\sigma\lambda)$$

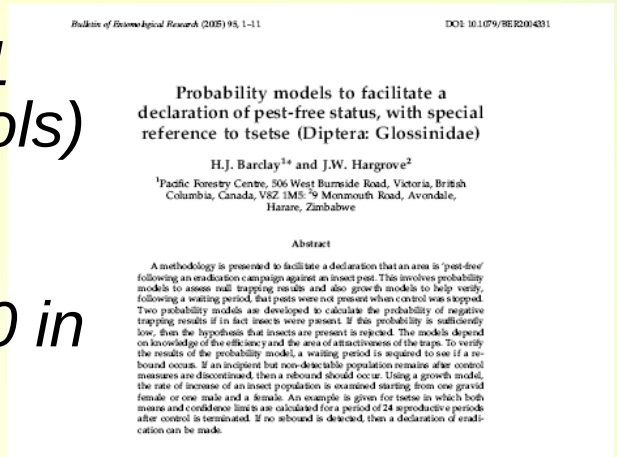
With:

***S** : number of traps deployed in the total area*

***t** : the number of days for which each trap is operated*

***σ**: the trap efficiency (estimated at 0.01 from Mark-release-recapture protocols)*

***λ**: the population density (number of insects / area of suitable habitat): minimal resident population set to 10 in the absence of control measures*



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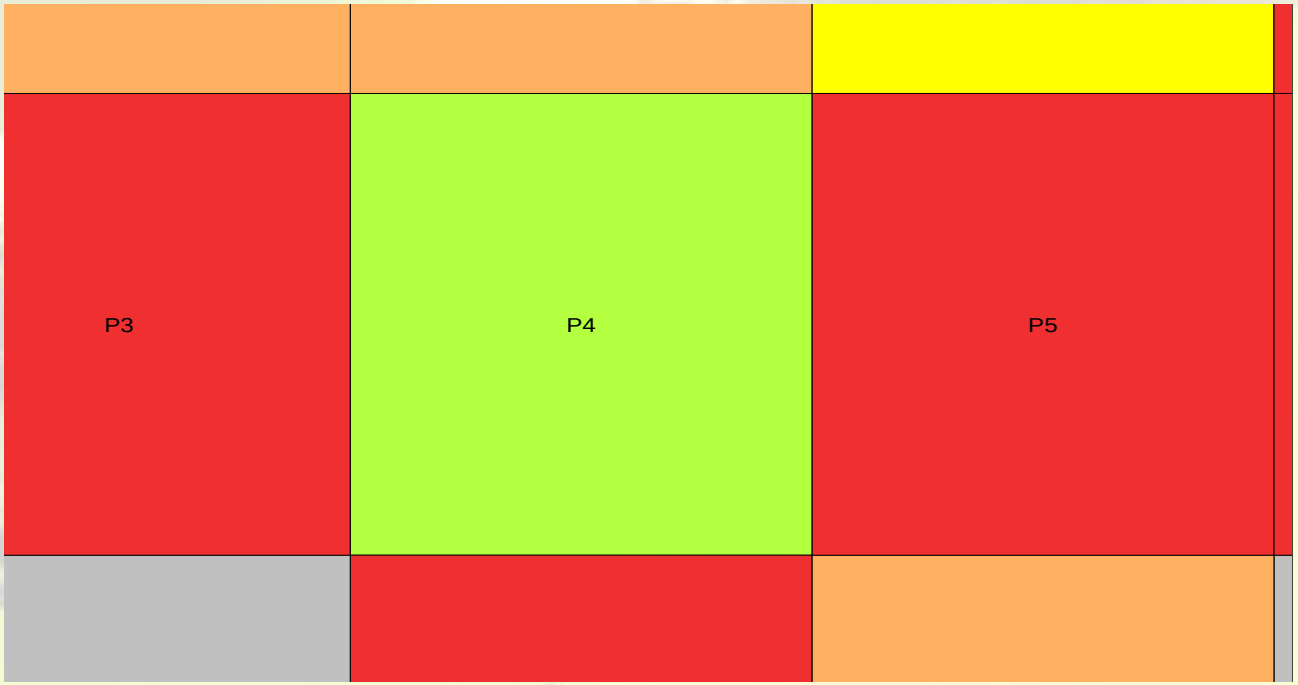
Implementation of the probability of presence despite 0 catch

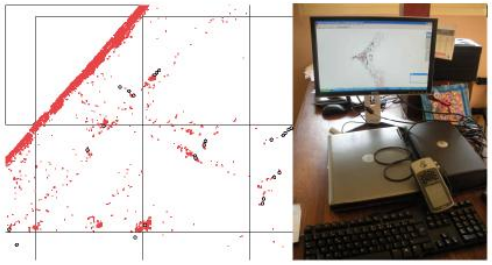


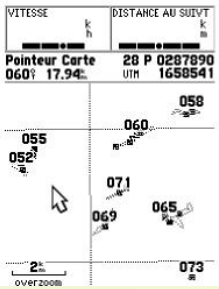
Probability of presence

Not sampled	(163)
1	(16)
0,1 - 1	(29)
0,05 - 0,1	(3)
0 - 0,05	(23)
No wet area	(60)

$$p = \exp(- St\sigma\lambda)$$

Entomological sampling scheme





Preliminary surveys
(definition of habitat)

Remote sensing
(mapping habitats)

GIS

GPS

Presence probability

Additional sampling

Distribution map
(with quantified accuracy)

$p = \exp(- St\sigma\lambda)$

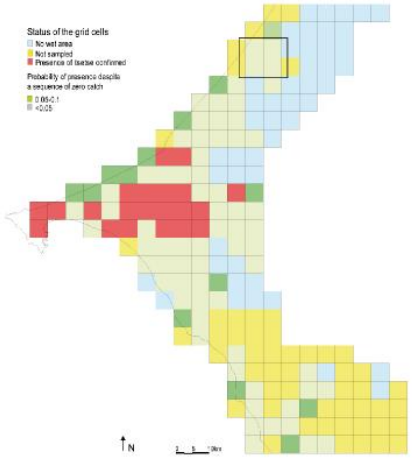
With:

S : number of traps deployed in the total area

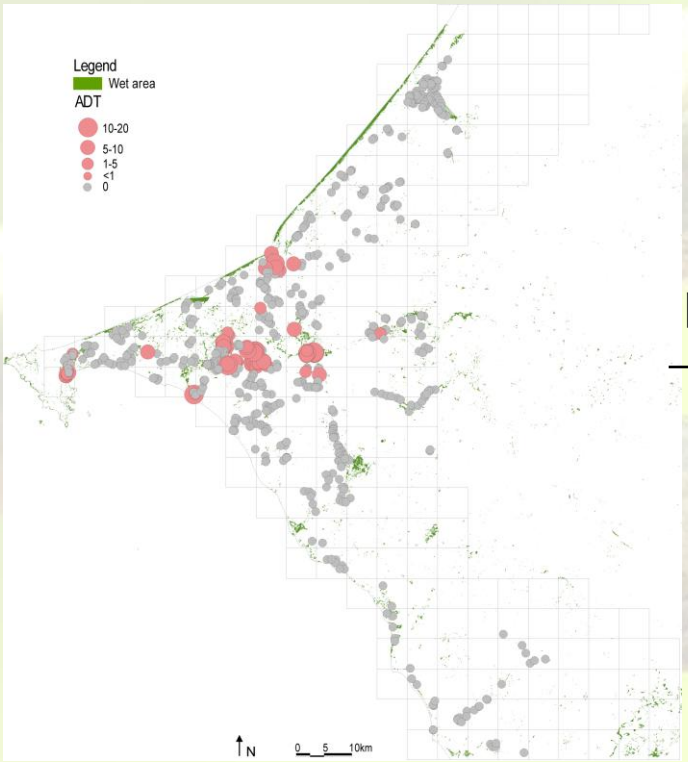
t : number of days for which each trap is operated

σ: the trap efficiency (estimated at 0.01 from Mark-release -recapture protocols)

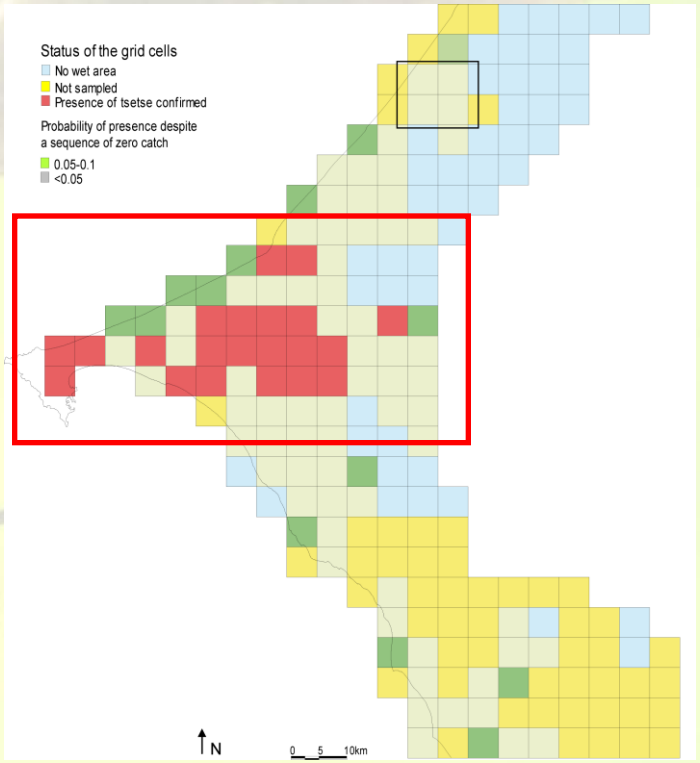
λ: the population density (number of insects / area of suitable habitat): minimal resident population set to 10 in the absence of control measures



✓Target population defined



p = exp (- *Stσλ*)



Probability of presence quantified -> inclusion of the grid cells into the target area when p (presence)>0.05 + Buffer area of 5km (active dispersal)

5. Recommendations to the tsetse national control campaign

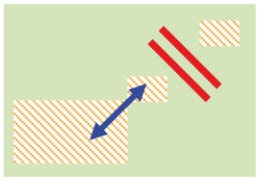
- Confirmation of the isolation of the target populations + absence of intermediary populations confirmed by entomological results (120km without tsetse between the Niayes and the southern tsetse belt) -> Eradication strategy advised to the vet services
- Interest of combining population genetics and remote sensing to define a target populations
- Perspectives: better definition of the suitable habitats using population dynamics models

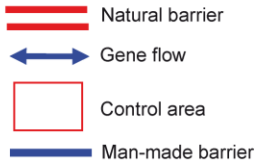
Feasibility study

Entomological study

Definition of the distribution of the target population (entomological sampling using GPS, GIS and Remote sensing)

Quantification of gene flows between the target population and the neighbouring populations (population genetics, MRR)



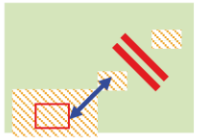


Socio-economic study

Positive cost/benefit ratio of the control campaign or food or health security

Estimation of the long-term socio-environmental impacts

I. Elimination impossible



Decentralized program (herder associations)

Moderate financial investment

Sustainable local actions

A. Trypanosensitive cattle

1. Epicutaneous treatment (hand spraying, pour-on, foot-bath)
2. Impregnated targets

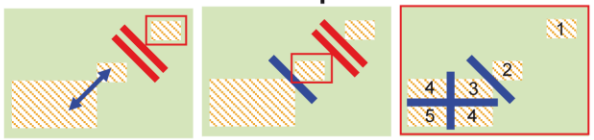
+

Chemoprophylactic and chemocurative treatments

B. Trypanotolerant cattle

No vector control

II. Elimination possible



Isolated or isolable population, or sequential treatment possible

Centralized Program (public agency or private agency mandated by the herder community)

Large and sustainable financial investment (international funding), global short or medium term actions

Savannah group
Subgenus *morsitans*

Wide area

A. Absence of thick vegetation or hilly landscape

1. Sequential aerial spraying

B. Presence of thick vegetation or hilly landscape

1. Sequential aerial spraying
+
Sterile insect technique (aerial releases)

C. Small area

1. Epicutaneous treatment
2. Impregnated targets
3. Targeted ground spraying

Riverine group
Subgenus *palpalis*

D. Wide area

1. Sequential aerial spraying
+
Sterile insect technique (aerial releases)

E. Small area

1. Impregnated targets
2. Epicutaneous treatment
3. Targeted ground spraying
+
Sterile insect technique (ground or aerial releases)